4.0 Test Article Selection for Baseline Tests

Test article selection from the family of seats is dependent on the installation and, in particular, the seat track. Installation on a different seat track will require re-substantiation and, in most cases, additional tests.

4.1 Structural Tests (reference section 25.562 (c)(7) and (c)(8))

Substantiation of the 16g longitudinal load condition for each family of seats:

1) Determine the 9g forward static interface loads (or any other standard load) for all seats. It is generally accepted that the interface loads calculated at 0° are sufficient to determine the most critical seat. Special seat design features *may* require interface load calculations that would take into account the aircraft tapered sections. All occupancy variations and combinations shall be considered for each seat (from unoccupied to fully occupied). The critical test case may be determined by analysis (FEM or static interface loads) and also by using test data.

2) Group the seats into two groups. Seats with two legs and seats with more than two legs.

3) For each group of seats (see attached decision chart to clarify the items below):

   a) Compare the aft fitting resultant loads of the seats within each group and identify the seat with the highest load. This seat will be tested.

   b) Subgroup the seats by lateral leg spacing.

   Note: For groups with more than two legs, define a subgroup of seats based on the minimum lateral leg spacing.

   c) Identify the subgroup with the minimum (narrowest) lateral leg spacing and identify the seat with the highest seat leg aft fitting resultant load within that subgroup.

   d) If the aft fitting resultant load of the seat identified in step 3c (narrowest leg spacing) is greater than 80% of the highest load found on the seat selected for test in step 3a then the seat identified in step 3c will also be tested. (See paragraph 6.b of AC25.562-1A and chart below).

   e) Conduct a 16g longitudinal dynamic test of each seat selected in steps 3a and 3d from each group. If the seats selected in steps 3a and 3d do not result in testing the seat with the most critical beam load, that seat should be tested as well.

f) The occupancy that produced the highest calculated seat leg resultant tension reaction in the aft fitting shall be used for the test, unless the load of the fully occupied seat is within 10% of the highest seat leg load. Due to the statically indeterminate nature of seat structure, there are assumptions used to calculate interface loads, which will result in some uncertainty. Data indicate that calculated reactions within 10% of one another are effectively equivalent. In such cases, a fully occupied seat will impart an overall greater load than a partially occupied seat. Therefore, if the fully occupied seat leg load is within 10% of the highest loaded seat leg, test the seat fully occupied.

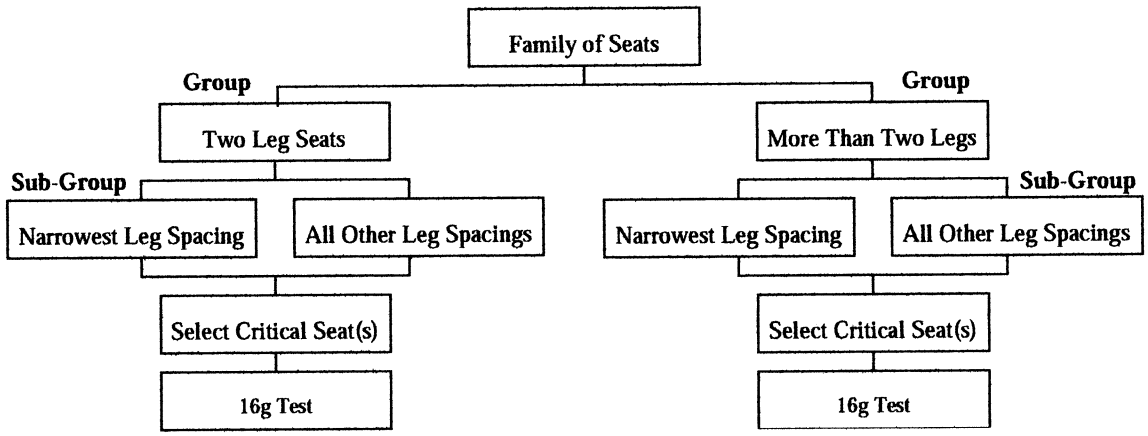
g) Select yaw, pitch, and roll for test setup per guidance given in AC 25.562-1A.

Note: If any seat in the family is intended to be installed on canted seat tracks, the yaw angle for the test shall be 10° plus or minus the aircraft installation cant angle (if it is more critical) depending on which yaw angle maximizes the calculated reaction (a test yaw angle other than the minimum required may be used to accommodate the test fixture adjustment capability).

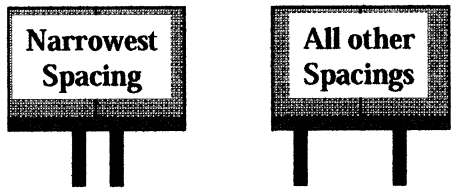
h) Baggage, life vests, and literature pocket contents shall be installed at each seat place, regardless of seat occupancy. A floor for the ATD's feet is optional for the 16g forward structural test. The floor may remain flat, or follow the warpage of the seat tracks. (Reference AC 25.562-1A paragraph 11.f)

i) Retention of a specific item of mass, including emergency equipment, need only be demonstrated once during the 16g longitudinal load condition and the item of mass may be restrained for all other 16g longitudinal tests. (Reference AC 25.562-1A, paragraph 6.a).

16g Test

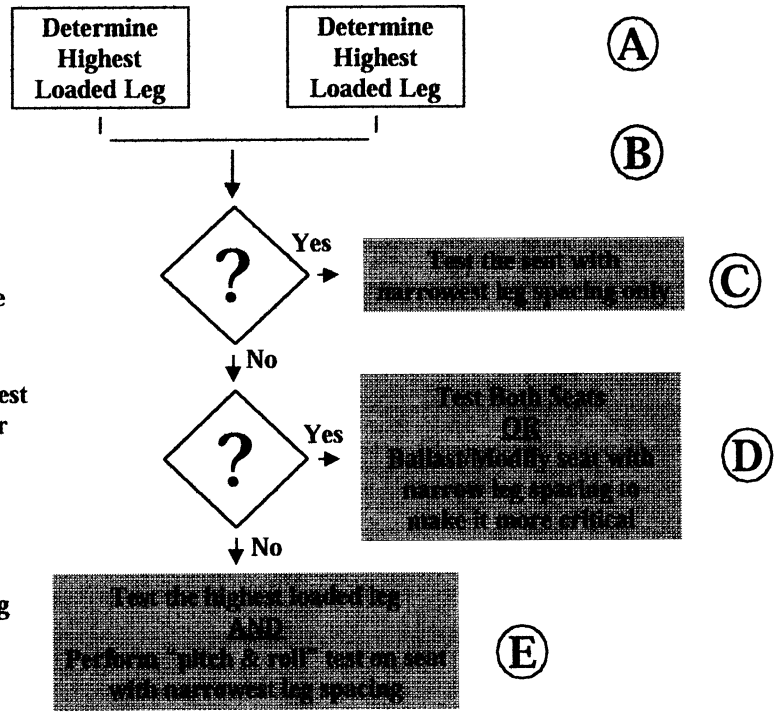


Structural Test Article Decision Tree



1) Determine9g Interface Loads

2) Compare the highest loaded legs



Question: Is seat with narrowest leg spacing the one with the highest interface loads in this group?

Question: Does the seat with the narrowest leg spacing have an interface load greater than 80% of the highest interface load in this group?

Final Choice: The highest interface load on the seat with the narrowest leg spacing is less than 80% of the highest interface load in this group.

Ⓐ 9g static interface loads are the generally accepted indicator of seat structure criticality. Based on this analysis, the highest loaded leg will indicate the most critical configuration to test. (note: other features may drive criticality (e.g beam bending, etc.) in addition to the interface loads analysis). Using 9g static interface loads, identify the highest loaded leg for the seats with the narrowest leg spacing sub-group and the highest loaded leg for the seat from the wider spaced-leg sub-group(s).

Ⓑ Compare the interface loads of the highest loaded seat leg from the sub-groups(s). It is generally accepted that the seat with the narrowest leg spacing will exhibit the highest pre-loads during "pitch & roll".

Ⓒ By testing the seat with the narrowest leg spacing, the test covers the highest loaded leg and the highest pre-load from "pitch & roll".

Ⓓ If the static interface loads for the seat with narrowest leg spacing is within 20% of the seat with the wide leg spacing, it cannot be easily determined which is the more critical to test. The pre-load from "pitch & roll" contributes more to the criticality of the seat with narrow leg spacing. Since the most critical seat cannot be easily determined, either test both seats, or modify/ballast the narrow seat so that it has the more critical interface loads and the highest pre-load from "pitch & roll". Test only the narrow seat. (Note: modification of the seat should be limited to relocating seat legs along a beam to create a more critical overhang. Modifications should not change seat hardware).

The 20% margin guideline was established from industry test data and represents a conservative estimate of leg pre-load forces over a large change in seat leg pitch. This number may be established uniquely for each seat family. Ideally, this value would be established based on pre-load test data compared to the peak resultant load from a 16g longitudinal test. A new ratio would be established for a seat model from test data as follows:

$$\text{Ratio} = \frac{\text{Pre-load test data (resultant load)}}{\text{Peak resultant load from 16g longitudinal test}}$$

Ⓔ If the highest static interface load on the seat with the narrowest leg spacing is less than 80% of the highest loaded seat in this group, it can be assumed that the narrow seat with the higher pre- load will not be more critical. Only the seat with the highest leg load need be dynamically tested. A check must still be made on the narrowest leg spacing seat to ensure the structure has enough flexibility to accommodate floor warpage. This seat should be placed on a static test fixture and the floor warpage applied. No dynamic test of this configuration is required. This is a test of the primary structure. No ATD's or other additions to test article/set-up are required.

For each family of seats, to substantiate the 14g down load condition:

1) Compare the aft fitting resultant loads of all seats in the family, regardless of the number of legs on the seat, and identify the seat with the highest load. This will usually be the same seat that was selected for the critical forward structural test. This one seat will be tested.

2) Conduct a 14g vertical dynamic test of the seat selected in step 1.

   a) Full occupancy shall be used for this test. (Note: This is to ensure the maximum compressive load is put on the structure).

   b) Life vests and literature pocket contents shall be installed at each seat place, regardless of seat occupancy. Ballast may be used for non-critical parts of the seat (e.g., under seat In-Flight Entertainment (IFE) boxes, etc.). However, if this test is also used to acquire lumbar loads, the criticality of parts should be assessed with that in mind. See discussion in section 4.3 regarding compliance with FAR/JAR 25.562(c)(2).

   Note: Weights representing under-seat baggage are not required for the 14g vertical test. The ATD's identified in the FAR/JAR 25.562(c)(2) part of this test selection process shall be instrumented to collect lumbar loads.

   c) Retention of a specific item of mass, including emergency equipment, need only be demonstrated once during the 14g vertical load condition and the item of mass may be restrained for all other 14g vertical tests.

   Note: Refer to AC 25.562-1A to address special design features (e.g. unique energy absorption features).

   A representative floor shall be included in the test set up for the ATD(s) feet.

4.2 Deformation for Egress

The seat permanent deformations (reference AC 25.562-1A Appendix 2) shall be measured in all tests in order to show compliance to 25.562(c)(7). In addition, seat back permanent deformations shall be measured in a test where the ATD head contacts the seat back (e.g., a row-to-row HIC test). These permanent deformations shall be used to show compliance to 25.562(c)(8). (Note: Deformations that are an artifact of test set-up orientation need not be considered.) Some of the seat permanent deformations will be evaluated for acceptability as part of the dynamic test results (seat pan rotation, 'B' vs. 'C'). Some of the seat permanent deformations will be used by the seat installer to evaluate the seat installation and aircraft interior configuration (seat forward, aft, side deformations, seat back forward and aft deformations, and deployment of deployable items). The seat installer shall use the seat permanent deformations to show an acceptable installation with regard to occupant egress of the airplane.

4.3 Occupant Injury Criteria (reference FAR/JAR 25.562 (c)(1-6))

FAR/JAR 25.562 (c) (1) - Upper Torso Restraint Tension Loads

The upper torso restraint tension loads shall be collected during a structural test where the seat is yawed in the direction that produces the highest tension load in the restraint system. Typically this is the yaw direction which puts the upper torso restraint over the shoulder of the ATD which is moved further forward as a result of the yaw.

If the 16g longitudinal test that demonstrates compliance to FAR/JAR 25.562(c)(7) is yawed in the appropriate direction, the restraint tension load data may be collected during this test and an additional test is not required.

If the 16g longitudinal test that demonstrates compliance to FAR/JAR 25.562(c)(7) is not yawed in the appropriate direction, an additional test must be added to the baseline testing. The test article for the additional test would be the same seat selected for the 16g longitudinal test that demonstrates compliance to FAR/JAR 25.562(c)(7). It would be yawed in the direction that creates the highest tension load in the restraint system, with the pitch and roll selected per the guidance in AC 25.562-1A.

FAR/JAR 25.562 (c) (2) - Lumbar Loads

1) The ATD lumbar loads shall be collected during the 14g vertical test that demonstrates compliance to FAR/JAR 25.562(c)(7). An additional test for collecting lumbar loads is not required in the baseline testing (except as noted below).

   a) ATD's instrumented to measure lumbar loads shall be placed in seat places which represent the stiffest load path from the center of the occupant place to the structure and the least-stiff load path from the occupant place to the structure. This requirement will typically result in two instrumented ATD's, but will not exceed three instrumented ATD locations in a single test.

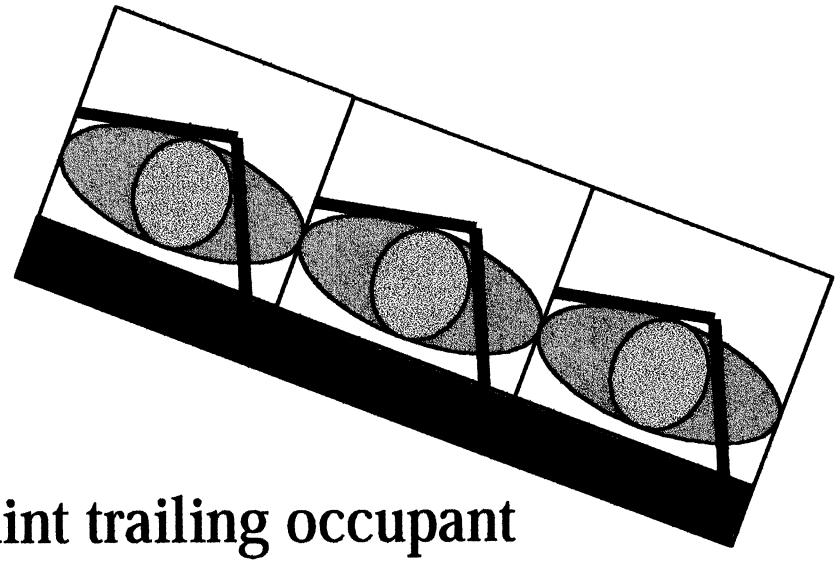
   Note: Refer to AC 25.562-1A to address special design features (e.g. unique energy absorption features) which may function differently, depending on seat occupancy.

If there is an item (e.g. IFE) or structure located at a specific seat place (typically beneath the seat pan) which may influence lumbar loads due to seat deflection and/or ATD contact, then lumbar loads must be addressed and substantiated for this location in addition to the locations identified above (either data showing no contact or an additional test(s) added to the baseline testing).

FAR/JAR 25.562 (c) (3) - Upper Torso Restraint Remains on Shoulder

For seats with a single upper torso restraint (e.g. a 3-point restraint), a test which demonstrates that the upper torso restraint strap remains on the ATD's shoulder during impact with the seat yawed in the most critical direction must be conducted. Typically, this is the yaw direction that puts the upper torso restraint over the shoulder of the ATD that is moved aft as a result of the yaw.

If the 16g longitudinal test which demonstrates compliance to FAR/JAR 25.562(c)(7) is yawed in the appropriate direction so that the restraint is over the trailing shoulder, the restraint retention may be demonstrated during this test and it is not required to add a test to the baseline testing.



Restraint trailing occupant
(Overhead view)

If the 16g longitudinal test that demonstrates compliance to FAR/JAR 25.562(c)(7) is not yawed in the appropriate direction, an additional test must be performed. The test article for the additional test would be the same seat selected for the 16g longitudinal test. This demonstrates compliance to FAR/JAR 25.562(c)(7), yawed in the direction most critical for the restraint strap to remain on the ATD's shoulder, and with the pitch and roll selected per the guidance in AC 25.562-1A.

For seats with a dual upper torso restraint, the 16g longitudinal test which demonstrates compliance to FAR/JAR 25.562(c)(7) is acceptable for demonstrating the upper torso restraint straps remains on the ATD's shoulder during impact and it is not required to add a test to the baseline testing.

High-speed test film/video of the test will be used to demonstrate that the upper torso restraint strap remains on the ATD shoulder during the impact.

FAR/JAR 25.562(c)(4) - Lap Belt Remains on Pelvis

The baseline and additional tests will demonstrate the pelvic restraint remains on the ATD pelvis during the deceleration pulse. It is not required to add any tests to the baseline testing.

High speed test film/video of all tests (baseline and additional) will be used to demonstrate that the pelvic restraint remains on the ATD pelvis during deceleration pulse. No additional tests are necessary to show compliance with this paragraph. Current guidance outlines camera placement and quantity if the lap belt angle is greater than 55° or less than 45°.

FAR/JAR 25.562 (c) (5) - HIC

1) Seat-to-Seat HIC

In an effort to reduce the regulatory burden and simplify/clarify the procedure for demonstrating compliance, the following procedure has been developed. This procedure should allow demonstration of compliance for HIC with two tests in the majority of cases. The procedure takes into account seat pitch, the relative position of the seat and the row behind it as well as range of occupant sizes. The intent of this procedure is to provide default conditions that can be used in lieu of conducting several tests, or performing lengthy analytical studies, and is adequate to demonstrate compliance.

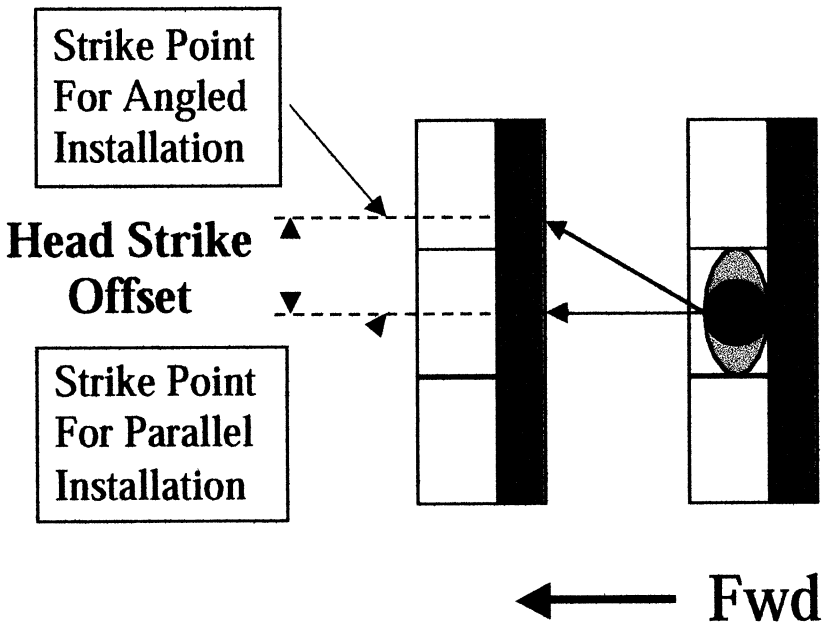
For each family of seats:

a) Identify the intended seat installation configurations from a seat-to-seat HIC perspective. This may include, but is not limited to:
   i) Seats on canted seat tracks, such that the seats are parallel, but are at an angle with respect to the airplane longitudinal axis.
   ii) Seats on staggered seat tracks such that the seat places, row-to-row, are staggered.
   iii) Non-parallel seat rows.
   iv) Staggered seating due to a change in the number of seat places.
   v) Different width seats which result in the seat places, row-to-row, to be slightly staggered.

b) Identify the range of intended seat-to-seat pitch.

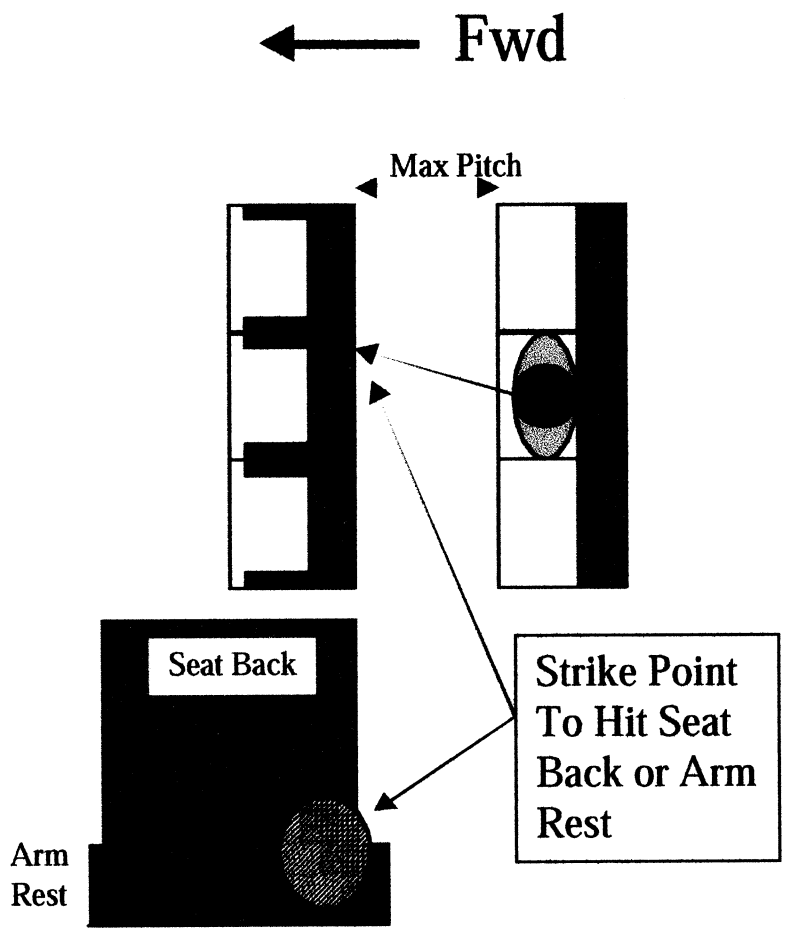
Note: For non-parallel seat installations (i.e., at the seat track break between the airplane constant and tapered sections) the SRP-to-SRP distance at the center of the seat place will be used as the seat pitch to determine minimum and maximum pitch when utilizing this test article selection procedure. All seat places (inboard to outboard) in the seat must be considered when determining the minimum and maximum seat pitch. Additional, unique seat pitches may be considered by choice.

c) For seats installed at an angle with respect to the airplane longitudinal axis (parallel rows or non-parallel rows), e.g., the rows in the tapered section of the aircraft:



i) Determine the head strike location of the 50% male ATD for the seats in the yawed installation configuration (inertia load direction parallel to the airplane longitudinal axis) using the path of the top of the ATD head.
ii) Determine the head strike location of the 50% male ATD for the same seats in a 0° yaw; parallel row installation configuration at the same seat-to-seat pitch as the yawed installation configuration.
iii) Calculate the "head strike offset - the distance between the two contact points determined in steps 1(c)(i) and 1(c)(ii), measured on a plane perpendicular to the airplane longitudinal axis.
iv) If the cumulative offset between the staggered seats plus offset due to the installation angle head is 6.0 inches or less, the additional seat angle may be neglected for the row-to-row HIC tests.
v) If the cumulative offset between the staggered seats plus offset due to the installation angle is greater than 6.0 inches, the additional seat angle must be included in the step 1(d)(i) evaluation and included in the test set up, as necessary.

d) For two of the same part number seats in the family, installed parallel to each other:



i) Determine the maximum seat pitch (within the range identified in step 1(b)) and the yaw angle (within the ±10° envelope plus additional seat installation angle per step 1(c)(v), if required) at which the 50% male ATD head impacts the lower portion of the seat back structure and/or the armrest structure. In most cases, the additional aircraft installation angle is not additive to both the plus and minus yaw angle (e.g. the analysis for an aircraft installation angle may be +10° and -14°).

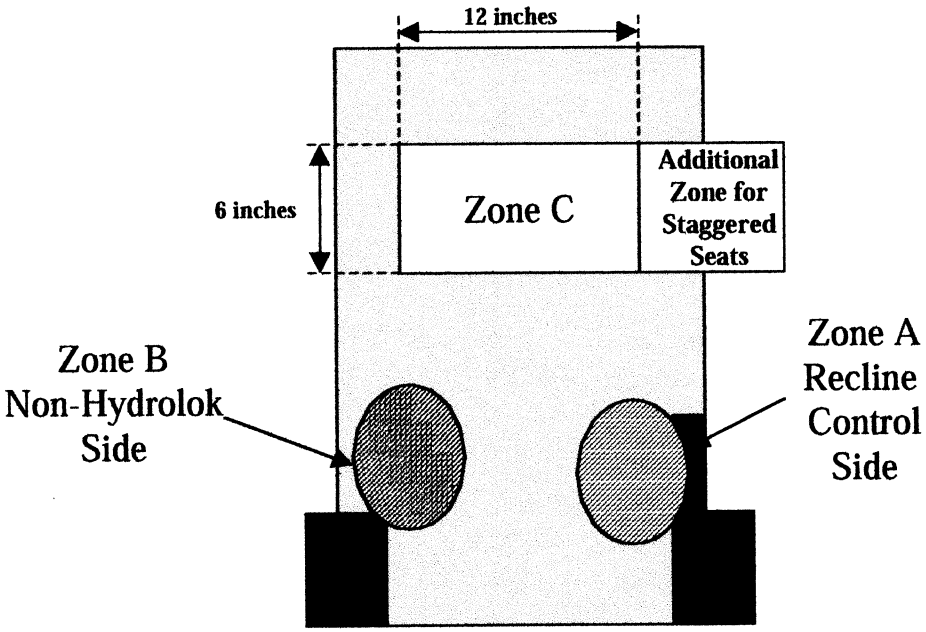
Note: Impact is defined as a solid strike by the ATD head and not a glancing blow.

ii) A test which is set up (seat pitch and yaw angle per step 1(d)(i)) with the yaw direction such that the ATD head strikes the side of the seat back with the seat recline mechanism shall be conducted (Zone A test).

iii) A test which is set up (seat pitch and yaw angle per step 1(d)(i)) with the yaw direction such that the ATD head strikes the side of the seat back without the seat recline mechanism shall be conducted (Zone B test).

Note: It is common for the recline mechanism to be positioned on the left side of some seat backs and the right side of other seat backs of the same assembly. Therefore, the seat-to-seat HIC test for Zone A and Zone B can usually be accomplished in one two row test using two instrumented ATD's with the yaw direction set to effect a head strike in Zone A by one ATD and Zone B by the other ATD. Alternatively, it may be possible to relocate one recline mechanism for test purposes. If this method is chosen, care should be taken to not alter the basic design. The intent of this procedure is to create a mirror image of the actual part, to simplify testing.

e) For same seats used in step 1(d), installed parallel to each other:



i) Determine the point of initial head contact by the 50% male ATD at the minimum pitch identified in step 1(b) and at 0° yaw angle.
ii) Evaluate the area defined by a 6 inch high by 12 inch wide rectangle centered on the initial head contact point for structures that differ significantly from the initial contact point (i.e., telephone handsets, video screens, and oxygen mask container units).
iii) Determine which structure in the 6 inch by 12 inch rectangle is the most rigid in the direction perpendicular to the aft seat back structure.
iv) A test which is set up which produces ATD head contact with the structure identified in step 1(e)(iii) shall be conducted (Zone C test).

Note: Typically, the Zone C test will be conducted at the minimum seat pitch and 0° yaw. However, when the area of concern (as identified in step 1(e)(iii)) is not at the center of the 6 inch by 12 inch rectangle, the relative position of the seats in the two row set up must be adjusted to produce the ATD head contact desired. Lateral offset or vertical adjustment of the seats' relative position will ensure that a comparable head impact velocity as that measured from the normal position Zone C test is achieved, although other methods that achieve the same objective are acceptable.

f) For seats which have staggered seat places, row-to-row:

Note: Staggered seating can result from a change in the number of seat places, different width seat assemblies, or installation on staggered seat tracks to accommodate the airplane taper section.

i) If the row-to-row seat place is staggered, and the cumulative offset between the staggered seats plus offset due to the installation angle is 6.0 inches or less, the lateral offset between the seat places may be neglected and the row-to-row HIC tests identified above may be conducted without including the lateral offset.

ii) If the row-to-row seat place is staggered more than 6.0 inches, the actual staggered installation configuration must be considered. This may broaden the Zone C evaluation window and include more objects to consider for head strike. If a test representative of the actual staggered installation configuration is determined to be required (either in addition to, or in lieu of, one of the baseline tests identified above), the test set-up (yaw direction and angle, and seat pitch) shall be that which is determined to be critical for HIC.

Note: A staggered seat installation may prove to be the critical HIC evaluation for the airplane installation, if contact with armrests or other hard structure occurs. Such an installation may require additional testing beyond the Zone A and B evaluations in step 1(d).

g) For row-to-row HIC tests:
   i) Since this test is not considered the critical case used to demonstrate compliance to structural criteria, non-production seat tracks may be used, for example, steel track, or seat track from a different aircraft type may be used on this test.
   ii) Any seat or seat place that allows the ATD to strike the intended target area is acceptable.
   iii) It is acceptable to conduct the test with no ATD's in the forward seat row. The components attached to the seat back and the structure of the seat back which influence HIC must all be representative of the production seat for all seat backs or armrests which will be contacted by the ATD during the HIC test. This includes the mass/weight of the seat back, breakover mechanism, the structure of the armrest and contact area of the armrest. Other components or parts of the seat may be non-representative or deleted from the test article.
   iv) Weights representing under-seat baggage are not required for either seat row. All components that are part of the seat should be represented, at least, by ballast.
   v) Life vests and weights representing literature pocket contents are not required for the forward seat row.
   vi) A representative floor shall be included in the test set up for the ATD(s) feet.

h) For each row-to-row HIC test, a post test evaluation of the high speed film/video and evaluation of the seat back (e.g., chalk mark) must show that the intended ATD head strike was achieved with regard to location and head impact (solid head strike and not a glancing blow). If the intended ATD head strike was not achieved, an adjustment to the test set up and a retest may be required.

2) Collection of ATD Head Path Data to demonstrate no head contact with aircraft interior features (usually front row seats).

Note: It is acceptable to collect ATD head path data in the 16g longitudinal structural test.

Note: This procedure only selects a test article for the collection of head path data. Additional analysis will be required to assess the specific interior configuration (e.g. translating the yawed head path into aircraft coordinates, evaluating the airplane interior for potential head strikes using the head path data collected.).

For each family of seats:

a) Conduct a 16g longitudinal dynamic test of the seat selected in 16g longitudinal structural test identified in section 4.1 above. If more than one 16g longitudinal structural test is identified in section 4.1, select the seat with the greatest overhang to collect head path. It is acceptable to use the opposite-hand part for this seat.

b) The occupancy used in the 16g longitudinal structural test shall be used for this test.

c) The test will be conducted with no yaw, no pitch, and no roll. Representative seat track is not required for this test, since structural attachment substantiation is not under consideration (e.g. steel tracks may be used on this test).

d) The head path data of the ATD expected to move the furthest forward due to structural deformation (usually in the most overhung seat place) should be collected. The most overhung seat place is the outer (left or right) seat place with the greatest distance from the centerline of the seat leg to the outer edge of the seat.

Note: It is acceptable to conduct additional head path tests of this type on other seats to collect head path data for specific seat places.

It is also acceptable to install a bulkhead, or rigid vertical wall, at the minimum design set back from the bulkhead into the test set-up for the purpose of showing no ATD head contact during the test. It is not required for the bulkhead used in the test set-up or material to be representative of the production aircraft interior component. This is because the test is conducted to establish if head contact occurs for a specific setback distance, and the location of head contact by a 50% ATD in those cases where it does. It is the responsibility of the seat installer to utilize this data to demonstrate an acceptable installation.

e) Baggage, life vests, and literature pocket contents shall be installed at each seat place, regardless of seat occupancy. Items of mass on the seat (e.g. under-seat IFE boxes) may be replaced by ballast.

f) Retention of items of mass need not be demonstrated in this test and items of mass may be restrained for the test.

g) A representative floor shall be included in the test set up for the ATD(s) feet.

3) Large Clearance Installations

a) Installations behind another seat or interior component where the distance between the seat SRP and the aft-most point on the seat or interior component is greater than 50 inches do not require dynamic test data to substantiate the HIC criteria. This is based on substantial industry data that demonstrates a seat passing structural criteria will not have a head path that extends beyond 50 inches from SRP. Current guidance for head/floor strikes and occupant/occupant strikes is contained in the current HIC-Lite guidance and is considered acceptable.

Note: Front row HIC compliance is outside the scope of the current task, but should be included in the comprehensive guidance that will be issued for 25.562 compliance.

FAR/JAR 25.562 (c) (6) - Femur Loads

1) Row to Row Femur Data Collection

a) The ATD in the Zone C minimum seat pitch, 0° yaw of the row-to-row HIC test selected shall be instrumented for the collection of femur loads. Each leg shall be instrumented. Alternatively, previous test data from a similar seat may be used to show compliance with the femur load requirement.

2) Collection of ATD Knee Path Data for Use in Femur Load Compliance (Front Row)

Note: It is acceptable to collect ATD knee path data in the 16g longitudinal structural test. Additional analysis will be required to assess the specific interior configuration (e.g. translating the yawed knee path into aircraft coordinates, evaluating the airplane interior for potential knee strikes using the knee path data collected).

a) The knee path data of the ATD in the most overhung seat place may be collected during the test that collected head path used to show compliance for 25.562 (c) (5). The most overhung seat place is the outer (left or right) seat place with the greatest distance from the centerline of the seat leg to the outer edge of the seat. An additional test to only collect the knee path data is not required provided it is collected during the same test that collects the head path.

Note: It is acceptable to conduct additional knee path tests of this type on other seats to collect head and knee path data for specific seat places.

b) The knee path data collected via the high speed film/video will be used show no knee contact with any aircraft interior components in the production installation. If this analysis of the seat installation/interior configuration shows that the knee will strike an aircraft interior component, additional testing which collects the femur load will be required.

3) Large Clearance Installations

Installations behind another seat or interior component where the distance between the seat SRP and the aft-most point on the seat or interior component is greater than 40 inches do not require dynamic test data regarding femur loads.